"Oil Heat" for the Architect and Engineer

Being a simple and concise explanation of modern oil heating

domestic oil heat

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"OIL HEAT" for the ARCHITECT and ENGINEER

Being a simple and concise explanation
of modern oil heating

by

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Oil Heat and the Architect and Engineer

The architect and engineer have played a leading part in the development of the oil heating industry. By training, conservative, they withheld their endorsement until the industry had proved that it was solid financially and had built up installation and service organizations able to guarantee efficient operation of their burners.

That this conservative attitude of the architect and engineer was well taken has been proved by the fact that where good burners, backed by reputable manufacturers and capable local organizations, have been installed the results have been uniformly satisfactory; whereas, in many instances good burners have failed due to improper installation or adjustment, or lack of a general knowledge of the art of oil heating.

There are now quite a number of correctly designed and well manufactured oil burners, and in every community of any size capable organizations have been established, backed by men who are equipped with a good knowledge of heating problems in general, as well as being expert in the installation and adjustment of domestic burners. Since the development of such capable local organizations, the architect has occupied a prominent place in the promotion of the oil heating industry, and has contributed materially to the advancement of the industry.

The American Home Owner has acquired an ever growing desire for comfort and automatic mechanical appliances that eliminate manual labor. The duty of the architect and engineer is to provide not only artistic, substantial and enduring construction, but comfort, convenience and an atmosphere of luxury to the degree that the home builder desires, or can afford.

Realizing the many complicated problems of ever increasing variety that confront the architect and engineer, we have in this book endeavored to summarize and simplify such problems as may be met in connection with Domestic Oil Heating.

Automatic Burner Corporation

Oil as a Domestic Fuel

Because oil heating has been so heartily accepted by the public, it might be interesting to mention some of the advantages that caused this acceptance. First, we must realize the many disadvantages attending the use of solid fuels which in themselves have created a demand for something better.

Little advance has been made in the handling of solid fuels. Between the earliest stoves and the present central heating systems, the principal difference is that only one fire instead of many must be maintained. There still remains the problem of handling, storing, stoking and shoveling approximately the same amounts of dirty, dusty fuel, removal of ashes, and the more or less manual regulation of the heating plant. Automatic regulating systems have been only partially satisfactory, as solid fuel is not readily adaptable to automatic control in small installations. Modern systems must be automatic.

Liquid fuels, on the other hand, are easily and cleanly handled and stored, occupy a minimum of space, and can be automatically fired and regulated. The development of automatic controls has kept pace with improvements in oil heating devices and represents one of the basic reasons for the enthusiastic public acceptance of oil heat. Without automatic control systems much of the safety, efficiency and economy connected with modern oil heating systems would be lost.

The modern oil heating system leaves little to be desired in the way of comfort, convenience and economy. Oil is delivered in tank trucks, unloaded through hose directly into the customer's tank without dust or dirt, automatically fed into the burner as heat is required, and the temperature always maintained at a uniform degree to suit the owner's requirements: an even temperature throughout the day and night, or cooler at night if desired, and warm again before it is time to get up in the morning.

The modern trend is towards the type of burner which is located entirely within the ashpit of the heater where it is safe from tampering or accidental damage and leaves the basement free for other uses.

Considering the many advantages of oil fuel, the cost is surprisingly low. Good oil heating installations can be had at prices ranging from $350 to $1000 or more, and the cost of heating, while generally more than for soft coal, is usually less than for anthracite, and in view of its many advantages, the saving in labor, dirt and drudgery, there is really no just basis for cost comparisons.

Cleanliness, convenience, comfort and health cannot be estimated in dollars.

The Practical Application of Oil Heat to Domestic Systems

The various units of all oil heating systems are substantially the same, consisting of: first, a tank for oil storage, which if small (not over 275 gal.) may be directly connected to the burner, or if larger must be connected thru an intermediate pump which controls the flow of oil; second, the necessary oil piping; third, the burner unit; and fourth, the automatic control system. Tanks and piping will be discussed later.

The function of the burner unit is to properly proportion and mix the oil with the air required for combustion. One gallon of oil requires approximately 1500 cu.

ft. of air. Any air supplied in excess of this amount is termed "Excess Air". All burners require at least a small percentage of excess air, the better ones operating with as little as 10 to 20%, while poor burners may require as much as 100 to 200% excess air. The percentage of excess air required to produce smokeless combustion is a very definite indication of the burner's efficiency.

As a practical example, the efficiency of a burner using 20% excess air would be 80%, whereas a burner using 200% excess air would be operating with an efficiency of only 40%, requiring twice as much oil.

The efficiency of a burner is governed, first, by its design, which must provide for properly metering and atomizing the oil and mixing it thoroughly with the required amount of air; second, by the installation and adjustment; and third, by the type of heater in which it is installed.

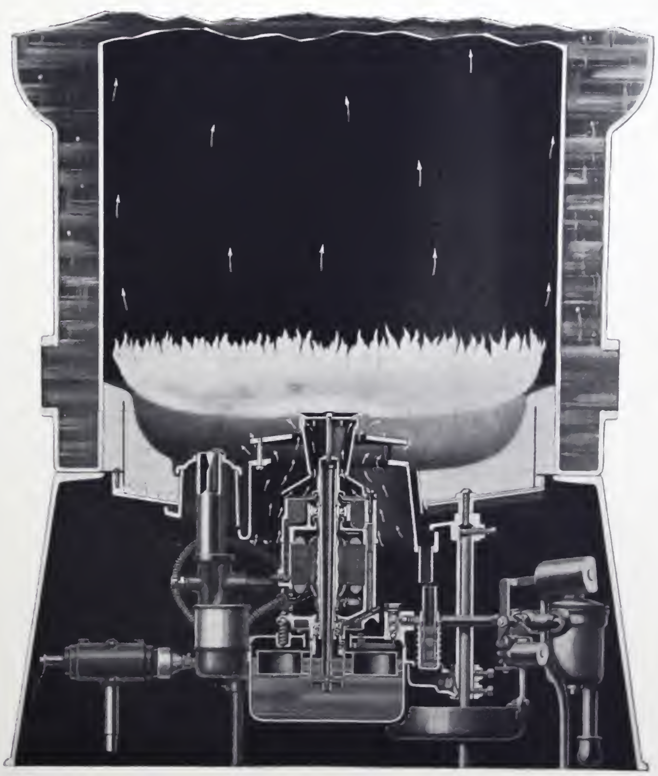
Some progress has been made in developing special boilers for oil burning. Such boilers combine the large fireboxes common to coal burning boilers with the long, narrow, flue passages peculiar to gas burning heaters. However, most oil burners must be installed in boilers designed for coal.

Heat is transmitted from flame to heater principally by two methods:

1. Direct radiation from a luminous flame to the firebox walls.
2. By convection, or the wiping of the hot gases against the heating surfaces.

In coal fired heaters approximately 50% of the heat is transmitted by radiation and direct conduction from the incandescent bed of fuel to the primary or direct heating surface. The secondary heating surface is relatively inefficient. This fact must be kept in mind when adapting oil burners to heaters designed for coal. For this reason the typical bright orange flame is regarded as being the most effective in ordinary boilers, approximately 30% of the heat developed being transmitted directly to the firebox walls.

The color in such a flame is produced by tiny particles of incandescent carbon which provide a very effective means of radiating heat. Non-luminous or slightly luminous, bluish flames, which are accepted as good gas-burning practice, are not the best for oil burners, particularly when installed in boilers designed for coal. Blue flame burners are generally more quiet in operation and for this rea-



Cross Section View of ABC Type E Oil Burner

son have found a ready market. However, the noise produced by a properly designed orange flame burner is almost negligible, and the efficiency relatively high.

The efficiency of heat absorption is indicated by the temperature of the gases leaving the heater, or actually in some cases the temperature at the chimney top, where the heat radiated from the smoke pipe and chimney is delivered within the building. The percentage of excess air required, and the combustion efficiency of the burner, are determined by the percentage of carbon-dioxide in the flue gases. An analysis showing 15% CO_2 indicating perfect combustion with no excess air; 12½% CO_2, approximately 25% excess air; 10% CO_2, 50% excess air, etc. 12½% CO_2 is generally regarded as a high standard as some excess air must be allowed to take care of draft changes and other slight variations in operating conditions.

The Orsat Flue Gas Analysis Apparatus is quite simple to operate, and by using the curves given in Fig. 1 immediate and quite accurate estimates of efficiency can be obtained without complicated calculations.

In using Figure 1, start on the right hand side at the value of CO_2 found by Orsat test, run straight across to the "Excess Air" curve, which indicates directly the percentage of excess air corresponding to the CO_2 value. From this point, follow up or down to the proper "Stack Temperature" as indicated by the stack thermometer, then to the left where the percentage of "Sensible Heat Loss" will be found. The Sensible Heat Loss includes only the heat carried away by dry stack gases. To this must be added the loss in water vapor (not condensed) that results from the combustion of the hydrogen in the oil. As the

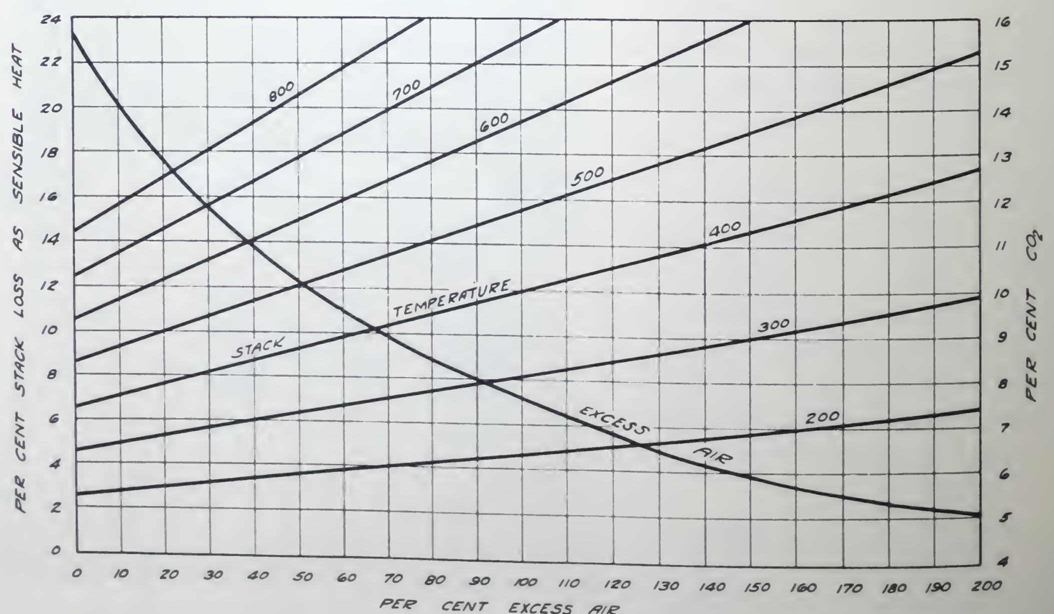


Figure 1—Stack Loss

percentage of hydrogen is fairly uniform, this loss may be regarded as a constant, approximately 6.8%. As the better burners produce no appreciable amount of carbon monoxide, the CO loss may be neglected.

Efficiency = 100——(Sensible Heat Loss + 6.8%.)

Figure 2 shows graphically the loss in efficiency due to overloading an ordinary cast iron boiler and also the advantage of maintaining a relatively high CO_2 content in the flue gas.

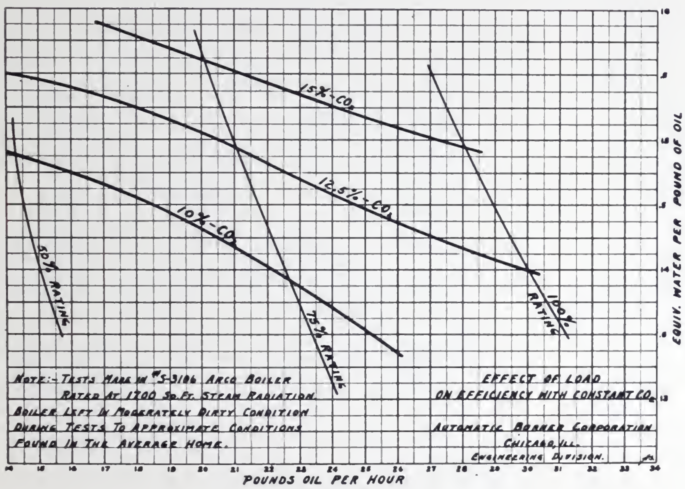


Figure 2

The Cost of Oil Heat

In spite of the fact that oil heat offers so many advantages in handling, cleanliness and temperature regulation, it is often desirable to know just how the cost in dollars compares with the cost of other fuels. Such a comparison, to be of real value, should make allowances for the following items:

1. Saving in basement space, either in original excavation or in making room available for other uses.
2. Saving on redecoration and cleaning.
3. Saving in manual labor, particularly where women care for the heater.
4. The greater degree of comfort attained through atmospheric temperature control.
5. The more efficient use of liquid fuel.

All except the last item can be left to the judgment of the Architect and Home-Owner.

The actual dollar cost of heat on this basis then depends on the efficiency with which the various fuels can be fired, the potential heating value of the fuel and the unit cost of each delivered into the house.

Efficiency

Laboratory and field tests generally indicate the average seasonal efficiency to be expected with each fuel as follows:

Coal—in ordinary heaters........40 to 50%
Oil—in ordinary heaters........50 to 70%
Oil—in specially designed heaters 60 to 80%
Gas—in specially designed heaters 70 to 80%

With a good standard boiler and coal properly fired, we can assume an efficiency of 50%.

With one of the better oil burners in the same heater, we can obtain an efficiency of 70%.

Gas, on account of cost, is not to be considered except for use in especially designed heaters where an efficiency of 80% can be attained.

An oil burner being primarily a gas producing machine can produce results comparable with gas, when installed in specially designed heaters. However, we generally consider oil as used in heaters

designed for coal. In either case, various oil burners will operate with quite large variations in efficiency. The efficiency of the burner as a combustion device is based on the amount of excess air required to produce smokeless combustion. This feature is of particular importance, as special heaters must of necessity have smaller, more tortuous flues, which are more susceptible to soot deposits than those in heaters of standard design.

It must also be understood that automatic control throughout the season is responsible to a great extent for the higher efficiencies obtained with liquid fuels.

The B. T. U. Values of the various fuels are well known:

Coal—10,000 to 14,000 B. T. U. per lb. average 12,000

Oil—average furnace oil, B. T. U. per gal 140,000

Gas—Manufactured, B. T. U. per cu. ft 550

Unit Cost: Accurate data on the unit costs of the various fuels is obtainable in each locality.

Comparison: A comparison of fuel costs can be made, based on the above data.

Comparing Coal and Oil

(1) 1 Ton of coal, 2000 lbs. at 12000 B.T.U. per lb. = 24000000 B.T.U.

At 50% efficiency 1 ton of coal delivers 24000000 × .50 = 12000000 B. T. U.

(2) 1 Gal. oil, 140000 B.T.U. per gal., at 70% efficiency delivers 140000 × .70 = 98000 B.T.U.

(3) Heat delivered per ton of coal *divided by* Heat delivered per gal. of oil, *equals* Gallons of oil equivalent to one ton of coal.

$$\frac{12000000}{98000} = 122.5 \text{ Gallons per ton}$$

On this basis, with oil at 7½c,

$122. \times .07\frac{1}{2} = \$9.19$

which is the cost of oil equivalent to one ton of coal.

Comparing Coal and Gas

(4) Heat delivered per ton of coal *divided by* Heat delivered per 1000 cu. ft. of gas *equals* Thousands of cu. ft. of gas equivalent to one ton of coal.

1000 cu. ft. gas at 550 B.T.U. per cu. ft. = 1000 × 550 = 550000 B.T.U. per 1000 cu. ft.

At 80% efficiency, 1000 cu. ft. of gas delivers 550000 × .80 = 440000 B.T.U.

$$\frac{12000000}{440000} = 27.3 \text{ Thousands of cu. ft.}$$

Gas for heating purposes generally costs not less than 75c per 1000 cu. ft.

27.3 × .75 = \$20.48, the cost of gas equivalent to one ton of coal. In general it will be found that oil will cost approximately the same as coal, and that gas will cost at least twice as much as either oil or coal.

The above figures may be altered to suit specific problems, but the same general principles can be used in making similar calculations.

It can be safely said, that the use of the best oil burners in standard heaters will not be objectionable from the standpoint

of fuel cost. The cost of oil heat will be governed by the type of burner selected, the intelligence used in its installation and adjustment, and the efficiency of the heater.

Classifying Oil Heating Systems

Oil heating systems may be classified in various ways, such as, the method of supplying the air for combustion, natural or mechanical draft; the method of feeding the oil, either by gravity or pump; the method of preparing the oil for combustion, vaporization or atomization; and sometimes by the type of flame produced, such as jet, cone, circular ring flame, circular flat flame, blue flame, orange flame, etc. These various designations should be used strictly in accordance with their technical meaning, altho they are often misused with confusing results.

The most common classification is according to draft.

Natural draft burners, of course, depend on the chimney draft to supply air for combustion.

Mechanical draft systems are provided with a motor fan or blower. In many burners a primary supply of air is furnished mechanically and mixed with the oil to start combustion, the secondary air supply to complete combustion being furnished by natural draft. This is probably the most effective method, as sufficient air is mixed with the oil mechanically to insure combustion of every particle, while the low velocity natural draft secondary air insures quiet operation, high combustion efficiency and high overall plant efficiency due to the low velocity of the gases leaving the heater. Natural draft also maintains a slight suction on all joints and cracks in the heater, preventing gases from being forced out into the basement. This advantage is particularly desirable in warm air plants, as it prevents gases from being forced into the leader pipes and carried to the living rooms.

Where mechanical draft secondary air is used, the chimney draft must be sufficient to prevent building up pressure within the firebox. Such excessive drafts cause an unnecessary waste of heat.

The Oil Supply may be either "gravity feed", that is fed to the burner by gravity from an elevated tank, or pump feed direct from a storage tank to the burner, or a combination of the two, where oil is pumped from the main storage tank into a small container attached to the pump and mounted (generally on the wall) above the level of the burner. The feed from the container to the burner is by gravity.

Oil can be prepared for combustion either by vaporization or mechanical atomization. Vaporization, as the name implies, is the process of gassifying or vaporizing the oil by the application of heat. This method is only applicable to the very lightest grades of oil, and owing to the slow starting characteristics when cold this method is not well adapted to automatically operated burners.

Mechanical atomization actually breaks the oil into minute particles or globules so fine that they immediately gassify and burn when thrown into the combustion zone. It might be said that all successful oil burners are of the mechanically atomizing type.

Several methods of mechanical atomization are in use:

(1) Forcing oil under high pressure thru small orifices or nozzles.

(2) Mixing the oil and primary air in small rotary compressors and discharging the mixture thru a nozzle.

(3) Throwing the oil by centrifugal action from a revolving disc or cup.

The most complete atomization is obtained by throwing the oil over the lip of a cup revolving at high speed.

Oil burners are further classified by the type of flame produced. A pot or retort burner has the flame more or less concentrated directly above the firepot in the center of the heater. The jet type burner throws a long thin jet of flame from the nozzle. The cone type has a wider spray angle and a shorter, heavier fire than the jet type. The rotary types produce either a thin circular ring of bluish fire around the firebox walls, or a flat circular sheet of orange colored flame that covers practically the entire grate area of the heater.

The Color of the Flame is sometimes used in describing a burner, the flames being generally designated as "Blue Flame" or "Orange Flame". Blue flames are usually quiet and can give highly efficient combustion results. However, on account of the dark color they radiate very little heat, thereby reducing the effectiveness of the direct heating surface. Unless the indirect heating surface is exceptionally well arranged (as in gas burning boilers) the efficiency of the heater is likely to be impaired. Orange flames, on the other hand, heat primarily by direct radiation and for that reason are best adapted to standard heaters in general use. With properly designed burners, orange flames are most efficient and can be produced with a negligible amount of noise.

Circular flames of both the ring and flat types are produced by vertical spindle rotary burners. The first burners of this type were driven thru bevel gears from a motor located outside of the boiler. General practice at present is to use a vertical motor in the ashpit, providing a direct drive for the atomizer and eliminating much unnecessary complicated mechanism.

It would appear that modern domestic burners are developing along two distinct lines: the high pressure nozzle type with a blower supplying low pressure air producing an orange-colored cone shaped fire; and the vertical motored rotary type, completely enclosed in the ashpit of the heater, producing a round flat orange-colored flame. The latter is better adapted to the usual type of domestic heater.

Oil Burner Ignition Systems

Domestic oil burners are designed for intermittent service, operating the heating plant at maximum efficiency when heat is necessary and cutting off completely when no heat is required. This makes it necessary to start and stop the burner according to the demand for heat. Consequently, some means must be provided for igniting the oil and establishing combustion at the beginning of each operating cycle. Various means of ignition are in use.

Oil Pilot Flame. When an oil pilot is used, a small amount of oil is burned continually while the burner is off. Because of the difficulty in metering such extremely small quantities of oil, and the generally smoky, lazy, carbon forming flame secured, this method is not used with any of the better types of burners.

Gas Pilots. Gas pilot flames are in common use and have proved to be satisfactory. However, if a gas flame sufficiently large to guarantee positive ignition is burned continuously, the cost of gas at ordinary rates is objectionable.

Electric Ignition Atomizing Burners may be ignited by an electric spark and transformers have been developed which produce an intensely hot arc over a gap of $\frac{3}{16}''$ or $\frac{1}{4}''$. The difficulty of keeping spark points or electrodes absolutely free from carbon, as well as keeping insulators free from soot and dirt, has caused more or less trouble and at this time gas ignition is looked upon as being the more dependable. When the area covered and the amount of heat produced by a large gas flame, as compared with a small electric arc is considered, the general use of gas seems to be justified.

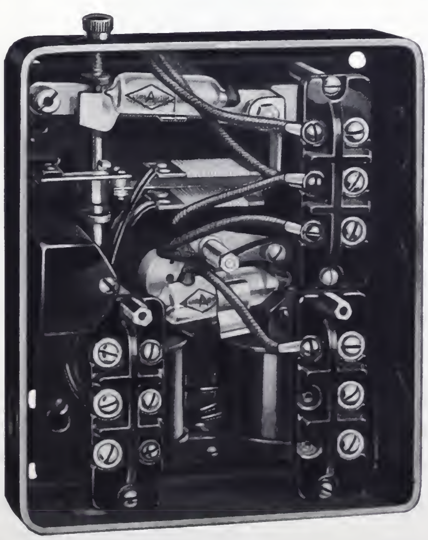
Gas-Electric Ignition: To reduce the cost of gas ignition, a large gas jet is sometimes turned on for a few seconds when the burner starts, an electric spark being provided to ignite the gas. This results in a very considerable saving in gas, but the various mechanical complications involved preclude its general use.

Magnetic-Gas Ignitors: The magnetic-gas ignitor developed by the Automatic Burner Corporation fulfills the demand for a positive, satisfactory gas ignition without mechanical complications and with a minimum consumption of gas. The magnetic-gas ignitor is built in one small compact unit supplied by a single gas connection. It consists of a small permanent gas pilot regulated by a very fine needle valve adjustment, and a magnetic valve controlling a large secondary gas jet. When the burner starts the magnetic valve opens the secondary jet, which is ignited by the permanent pilot. This intensely hot flame, ten or twelve inches long, insures unfailing ignition under all conditions. As soon as combustion is established the safety control on the burner cuts out the secondary gas jet. As only a very small flame, one or two inches in length, is required for the permanent pilot, and as the large gas flame is on only for a period of ten to twenty seconds at the start of each burner operation, the cost of gas is reduced to a minimum. The simplicity of the device insures dependable service.

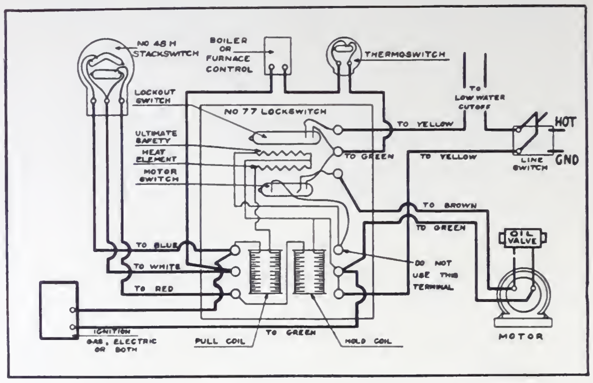
Automatic Control Systems

Automatic Control Systems are of two general types, high voltage and low voltage, according to whether the thermostat circuit is full 110-volt with approved wiring, or less than 25 volts using "bell" wire circuits.

Practically all controls are of the interlocking type, the various units being so inter-connected electrically that proper sequence of operation is assured, and so that in case of improper operation the controls go into "safety" which shuts off the burner completely until the reason for the failure has been corrected and the controls manually "reset" to re-establish the proper operating cycle. All control systems are arranged to start the burner automatically after a shut-down due to voltage failure.



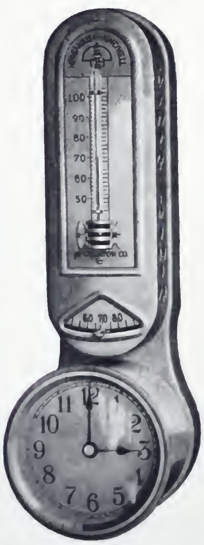
Lock Switch



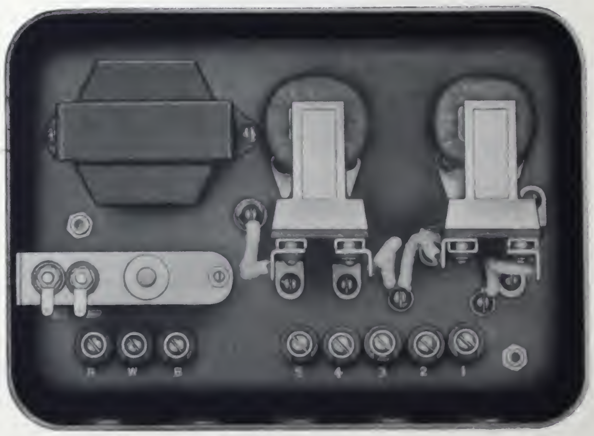
Wiring Diagram for Lock Switch

The principal units of a standard control system and their functions are as follows:

Boiler Control



Room Thermostat



Relay

The Room Thermostat: An automatic switch, responsive to room temperatures, designed to "make" an electrical circuit to the burner when heat is required, and to "break" the circuit when the desired temperature has been attained.

The Boiler Control: An automatic switch operated by pressure of steam boilers, or by temperature of hot water systems, to keep the pressure or temperature within desired limits.

The Furnacestat regulates the temperature of a warm air heater.

The Relay, known by various trade names, generally consists of one or more electro-magnets operating switches arranged to interconnect the various control units and the burner.

The Stack-Switch, also known as Pyrostat, Protecto-stat, etc., is a switch responding to the presence or absence of heat. It performs various functions such as cutting off the ignition after combus-

Stack Switch

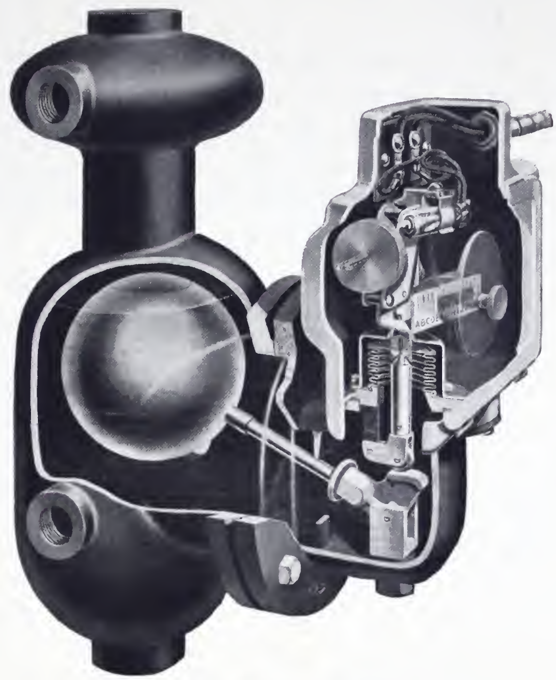
tion has been established, and preventing the burner from again being started until all gases have left the furnace.

The Time-Switch or "Safety" stops the burner entirely when for any reason proper, safe operation is not secured.

Surface Aquastat

Surface Aquastat: A water temperature control installed on the surface of hot water mains to simplify installations.

The Low-Water Cut-Off is a float operated switch that prevents the burner from operating when the water level in the boiler is below a safe point. The low water cut-off may be combined with the pressure control in one unit.



Low-Water Cut-Off

Oil Storage—Pumps—Piping—Gages

Storage Capacity Required: The oil storage capacity required depends on local conditions. Where good delivery service has been established from 50 to 100 gallons storage capacity per room is ample. The seasonal oil consumption in Chicago averages 250 to 300 gallons per room.

Types of Storage: Oil tanks are designated by their location such as:

1. Inside Exposed Basement Tanks.

2. Underground Tanks.

Inside Basement Tanks: Fig. 3. The size of inside exposed basement tanks is usually limited to 275 gallons capacity. Many city ordinances permit the use of two such tanks, connected to the burner thru a manually operated 3-way valve so that either tank may be used as desired, but not both.

This provides ample storage, 275 to 550 gallons, for the average residence up to about ten rooms. The use of inside storage tanks reduces installation costs and makes it possible for the average small-home owner to have oil heat.

Inside tanks are usually "obround" or rectangular in shape. Round tanks of 275 gallons capacity cannot be carried into the average basement, take up more space, and are more difficult to support.

Such tank installations must be provided with both an outside fill pipe, not less than 2″ in size, and an outside vent pipe not less than ¾″ pipe size although 1″ pipe is generally installed to provide a free vent when filling. Inside tanks must be mounted on non-combustible supports and securely anchored to prevent floating in case the basement is flooded with water. These tanks are generally provided with simple mechanical gages that indicate approximately the amount of oil in the tank.

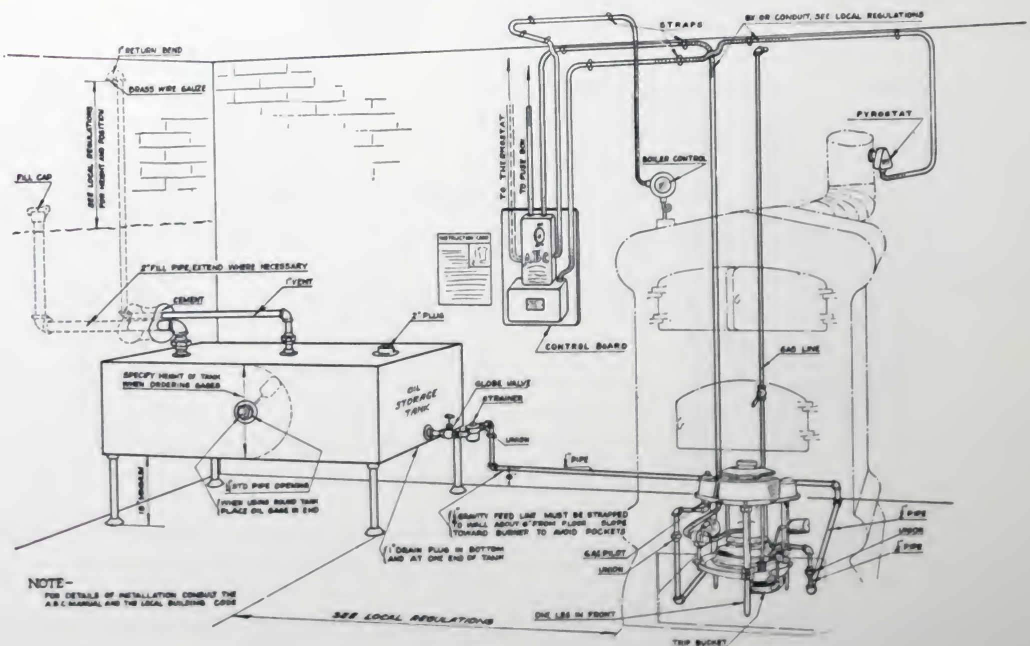


Figure 3

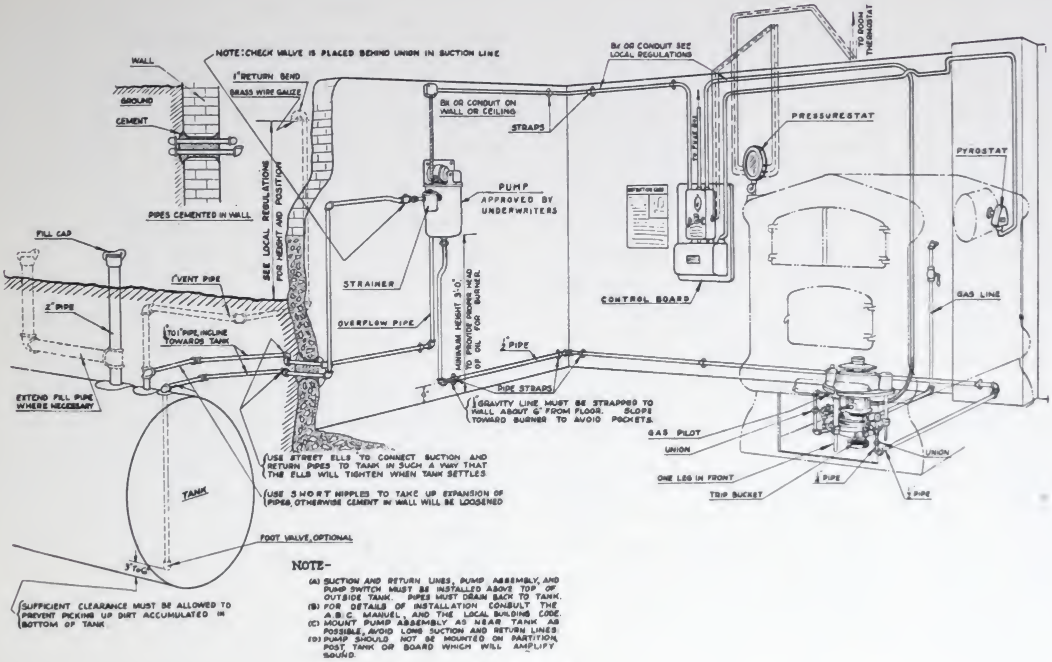


Figure 4

Underground Storage Tanks: Fig. 4. Where greater storage capacity is required, underground tanks are generally used. They are usually buried beneath the lawn, but when necessary they can be located under driveways, sidewalks or even beneath basement floors. The fill pipe should be brought to a convenient point and a vertical pipe run directly to the surface for gaging, pumping out water, etc. A vent pipe not less than 1″ diameter is required.

Underground tanks increase installation costs particularly where rock, quicksand or water are encountered, and service work on buried tanks and piping is sometimes difficult and expensive.

Underground tanks must be thoroughly coated on the outside with tar, asphaltum, or suitable rust-resisting paint. Tanks should not be located in cinders, ashes or other corrosive material.

Tank Construction: Tanks may be constructed of steel or wrought iron sheets formed and riveted or welded. The minimum thickness of metal depends on the capacity of the tank.

CAPACITY IN GALLONS	MINIMUM THICKNESS
1 to 285	16 gauge
286 to 560	14 gauge
561 to 1100	12 gauge
1101 to 4000	7 gauge
4001 to 12000	¼ gauge

All openings and pipe connections must be in the top of the tank, except that inside exposed tanks may have a drain plug in the bottom and an outlet bushing on the end near the bottom of the tank.

Oil Pumps: Various types of motor operated pumps are used to transfer oil from the outside storage tank either to a small intermediate supply tank or direct to the burner under pressure. The most satisfactory and dependable pumps are those combined in one unit with a small oil con-

tainer holding from one quart to one gallon. Such pumps generally have considerable capacity and are operated intermittently by means of a float switch in the oil container. The entire unit is mounted on the basement wall above the level of the outside tank, which eliminates the use of anti-syphon valves and provides sufficient head for feeding the oil to the burner by gravity. These pumps are designed primarily for suction. This type of unit is designated as an Automatic Wall Pump, and is installed as shown in Figure 5.

Pumps designed for forcing oil under pressure thru atomizing nozzles have proved more or less troublesome in the smaller sizes required for domestic work. Such pumps are located on the burner. As the tanks should be below the level of the pump, this means an excessive amount of excavation. Where it is impossible to excavate to such a depth, an anti-syphon device must be installed at the highest point in the suction line. Air leaks in the suction line are particularly troublesome, causing loss of suction, air-locking, pulsating flame, or the trapping of air at some point in the line where a sudden surge might carry it thru the burner nozzle and extinguish the flame altogether. Such an installation is shown in Fig. 6.

Piping: Either black or galvanized iron pipe, or brass may be used. It should be free of scale and preferably washed out when being installed. All threads should be clean cut with a sharp well-oiled die. Joints should be run in one or two threads before doping to prevent pipe dope from being forced inside the fittings.

All gravity lines should be graded so that no pockets remain for the accumulation of air, dirt or water.

All inside piping should be securely anchored in place, but so laid out as to

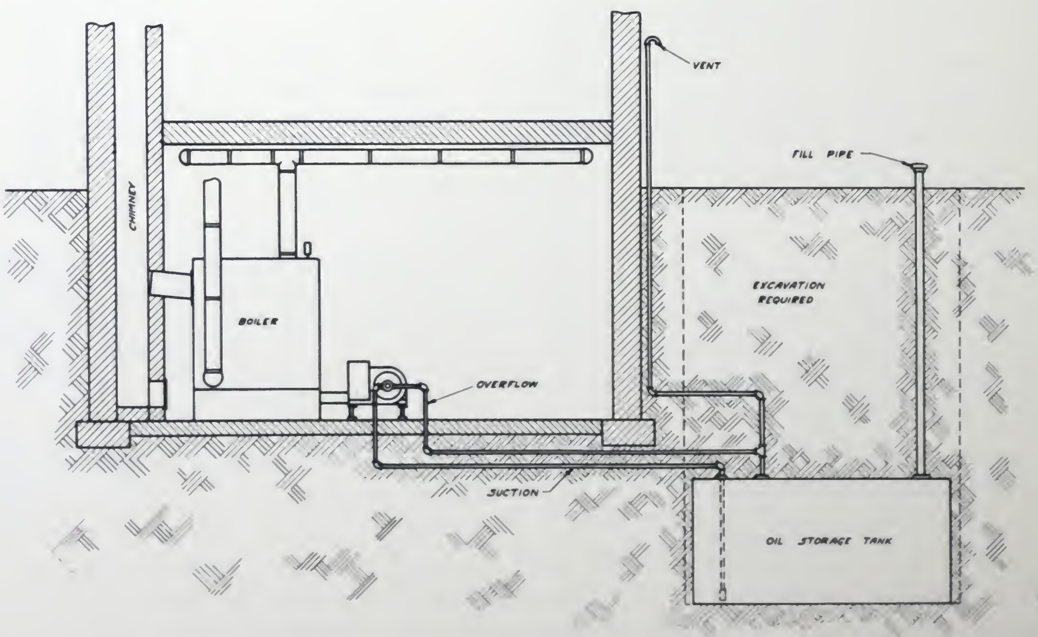


Figure 5—Underground Tank Installation with Pump on Burner Unit

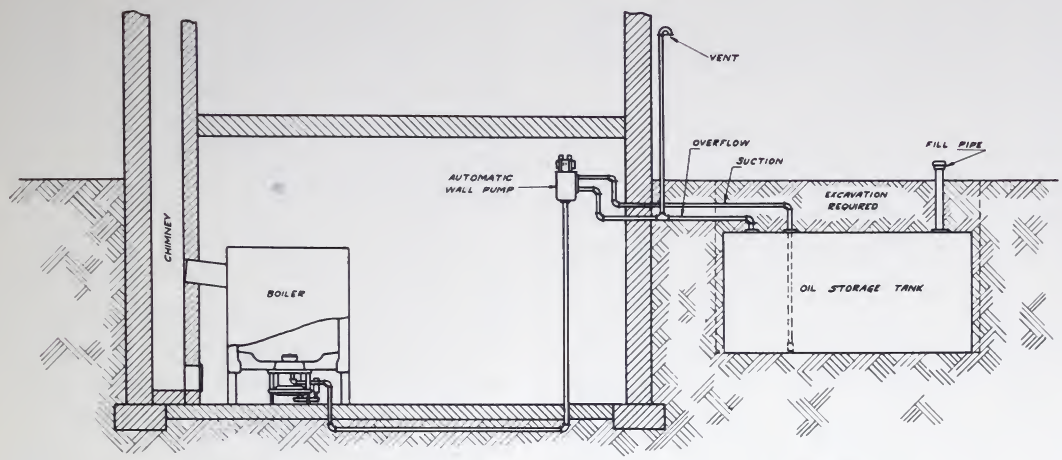


Figure 6—Underground Tank Installation with Automatic Wall Pump

provide for ordinary expansion and contraction.

Suction and return lines should be located below the frost line and graded to drain towards the tank. Both lines should have swing joints so that piping will not be damaged by settling or rolling of the tank. These joints usually consist of elbows arranged so that settling of the tank tightens the threads.

Size of Pipe: Underground suction and return pipes should not be smaller than ¾″, altho ½″ pipe is sufficiently strong for inside basement use. ¼″ pipe is permissible for short connections to the burner unit.

Tank Gages: Inside storage tanks are usually provided with a float operated gage. There are a number of good gages for use with underground tank installations. Where the customer objects to the use of an ordinary gage-stick, a suitable indicating gage should be installed.

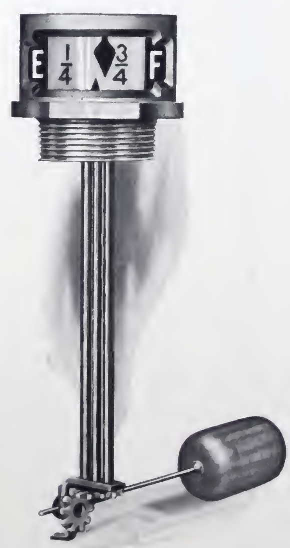
Boilers and Furnaces (Chimneys)

Classification of Boilers: Boilers for Domestic Heating are classified according to the material from which they are constructed as:

Cast Iron—Round or Vertical Rectangular or Horizontal Sectional

Steel—Fire Tube Water Tube.

Cast iron boilers have been extensively used but steel boilers of both the fire and water-tube types are becoming popular. There are also a number of boilers being constructed with copper water-tubes that show exceptional efficiency.



Float Operated Tank Gauge

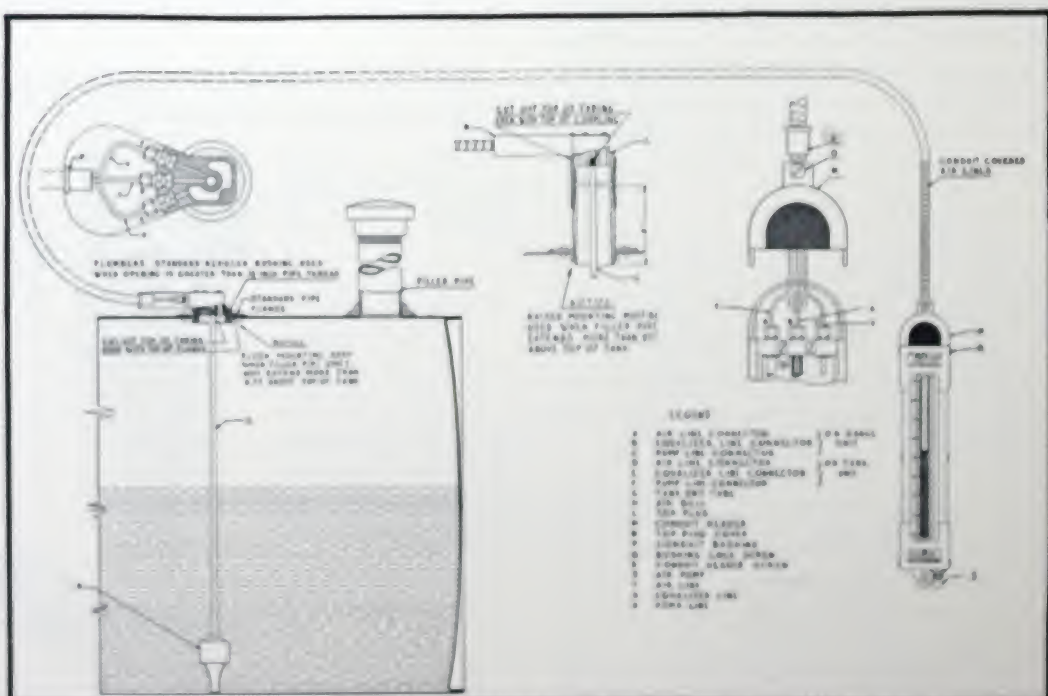
See Test on Knowlton "Water-Toob" Boiler, conducted by Armour Institute of Technology, page 30.

With a high temperature orange colored flame it is obvious that the direct heating surface of a boiler will be particularly efficient in connection with an oil burner. For best efficiency it is also necessary to have a large area of secondary heating surface. The ordinary round cast iron boiler, if supplied with plenty of intermediate sections will be found satisfactory for use with rotary burners, altho not so well adapted to other types. Sectional boilers should have a length about fifty per cent greater than the width to provide long flue travel, and a large number of small flue passages is advisable in order to secure maximum turbulence and the best "scrubbing" action of the hot gases.

Coal Burning Boilers generally have rather short flues, and since the secondary heating surface is limited it is of the utmost importance that burners producing the circular flat orange flame be selected for these boilers.

Steel boilers of either fire or water tube construction will be found very satisfactory for use with oil burners, particularly where the boilers are designed to pass the gases back and forth to provide effective use of the secondary heating area.

When selecting a boiler, it should be remembered that the burner is operated either "all on" or "all off",—therefore the boiler should be of ample capacity. It does not pay to force a small boiler, regardless of the ability of the burner to do so. Forcing a boiler will increase the stack temperature, and lower the overall



Hydrostatic Reading Tank Gauge

efficiency. See Page 4 of "Report of ABC Oil Burner" prepared by Ara Marcus Daniels, E. E., formerly Mechanical Engineer in charge of domestic oil burner tests for the U. S. Government. Copies of this and other test reports will be furnished by the Automatic Burner Corporation on request.

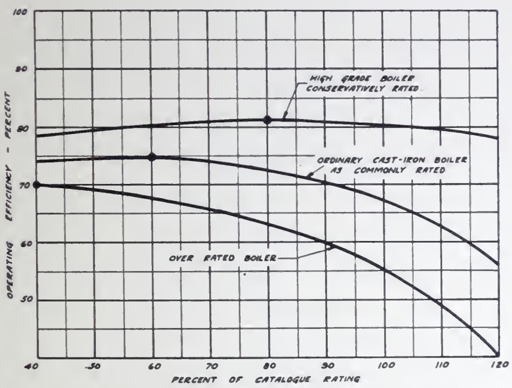


Figure 7—Overall Efficiency Curves

The Correct Boiler Size can best be determined by consulting the overall efficiency curve of the boiler to be used. Typical Overall Efficiency Curves are shown in Fig. 7. Cast iron boilers are usually most efficient when developing from 50 to 60% of their rating. Some boilers, however, are so conservatively rated that their efficiency curves are practically flat from 50 to 100% of rated load, so that no fixed percentages can be used. As the oil burner flame must be adjusted to deliver the maximum demand for heat, which is the total output of all radiation, plus piping, this demand should correspond with an efficient operating point on the overall efficiency curve of the boiler. This being understood, the following rule will obviously produce correct results:

Maximum demand or total Radiation *plus* Piping *divided by* Percentage of boiler rating selected for most efficient operation *equals* Boiler size.

After the correct boiler rating has been established, the dimensions of the boiler should be selected so that the width of the firebox will be no greater than necessary, the capacity of the boiler being built up by using a comparatively large number of sections. A six-section boiler is more efficient than a four-section boiler of the same rating.

The minimum satisfactory grate size in terms of net cast iron radiation can be expressed:

	STEAM	VAPOR	WATER
18″ min. width for first.......	500 ft.	600 ft.	800 ft.
Plus 2″ for each additional....	250	300	400

When using boiler rating instead of net radiation load, add 50% to the above radiation figures.

The diameter, width or length of the firebox should not be less than given by the above rule, and it is advisable to allow from 2″ to 4″ additional on each dimension for refractory material.

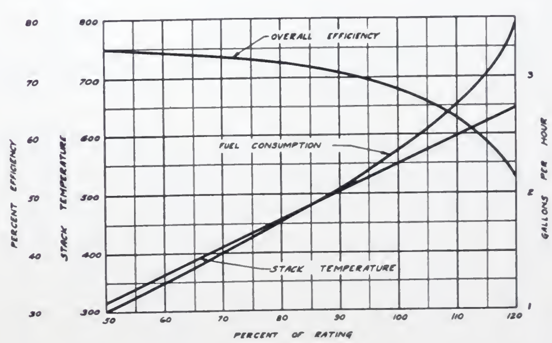


Figure 8—Loss in Efficiency—Gain in Stack Temperature and Increase in Fuel Consumption Due to Increase in Load on Ordinary Boiler

Fig. 8 shows very clearly the loss in efficiency, gain in stack temperature and increase in fuel consumption when a boiler is forced beyond the correct operating point.

Warm Air Furnaces: There is much to be said in favor of warm air heating, with the possibilities it offers for circulating properly conditioned air throughout the home. Much real engineering is being done on warm air systems, and many interesting developments will no doubt result during the next few years. Several systems are available that produce very satisfactory results.

Selection of Furnace: Welded, or riveted and welded, steel fireboxes and radiators are to be preferred in order to secure gas-tight construction. Some cast iron designs have been developed that meet all requirements in this respect. The old form of cast iron furnaces with cemented joints is not recommended for oil burner installations, altho burners utilizing natural draft secondary air are satisfactory in furnaces of this type.

Efficiency: Tests have shown that properly designed warm air furnaces are the equal in efficiency of the best boilers. The University of Michigan test on the Du Brie Warm Air Heater shows what high efficiencies are being secured.

Circulating Fans: Most of the troubles experienced in securing proper heat distribution and good circulation of warm air can be overcome by the use of circulating fans. These fans are either placed in the cold air returns or directly over the radiator.

Humidifying Systems: A humidifier is essential to best operation of a warm air system. Ordinary water pans are not entirely satisfactory, as they are often neglected. The addition of an automatic float valve to maintain the proper water level eliminates this fault. Complicated or delicate systems of valves and water tricklers are not recommended as corrosion and scale are likely to render them inoperative. Probably the ideal humidifier is one in which the water level is maintained automatically at a constant level and the water picked up by a revolving screen or some such mechanical means. These humidifiers can be rugged and simple, and might also serve as dust settlers or air washers.

Maintaining the proper degree of humidity provides increased comfort and more healthful atmosphere at lower temperatures with a corresponding saving in fuel.

Heat Insulation: Present day practice provides for thoro insulation of walls, roofs and floors. The use of efficient insulation with doors and windows properly weather stripped means that heat losses will be less, with a corresponding decrease in the size of radiators, piping and heaters, making a substantial reduction in the initial cost of the heating plant. It is claimed that in many cases the cost of the insulation is covered by the saving in the cost of the heating plant, and that annual heating bills are from ten to thirty per cent lower than in uninsulated buildings. A well insulated home is more comfortable, it being more evenly heated, less affected by outside weather conditions, easier to heat in cold weather and cooler in hot weather.

Chimneys: While it is true that chimneys that would not provide proper draft for coal have proved satisfactory with oil, it is advisable to install all chimneys strictly in accordance with best standard practice. New chimneys should be straight, tile lined, and of proper size and height. Old chimneys should be inspected to see that they are tight, clean and free of obstructions. The top of the chimney should be well above the peak of the roof and also above adjacent buildings to protect it from down-drafts. Round chimneys are most

efficient, with square sections next in effectiveness. Chimneys of long narrow cross-section should not be installed.

Selection of Burner

The selection of the most suitable burner for domestic installation is somewhat different from choosing burners for industrial purposes. For instance, the average domestic burner uses from one to five gallons of oil per hour. The high pressure nozzle type, which is well adapted to the atomization of large quantities of oil, is not entirely satisfactory for smaller quantities. The pressure required for atomization is substantially the same and the capacity can only be reduced by using a very small orifice, which is subject to frequent stoppage. Forced draft is necessary in large installations to insure an adequate air supply, whereas the chimney draft available in domestic installations is far in excess of ordinary requirements when the oil is properly prepared for combustion and a suitable means of supplying primary air is provided.

It is advisable to discuss briefly each feature as applied to domestic practice and select those features that are best adapted to domestic burners as the basis for our specifications.

Draft: As discussed above, the primary air should be supplied by mechanical means, the secondary by natural draft.

Draft Regulation: A constant chimney draft is desirable with any type of burner. Several draft regulators are on the market, the most satisfactory consisting of a balanced door which admits cold air into the smoke pipe as the chimney suction increases beyond the desired amount. These

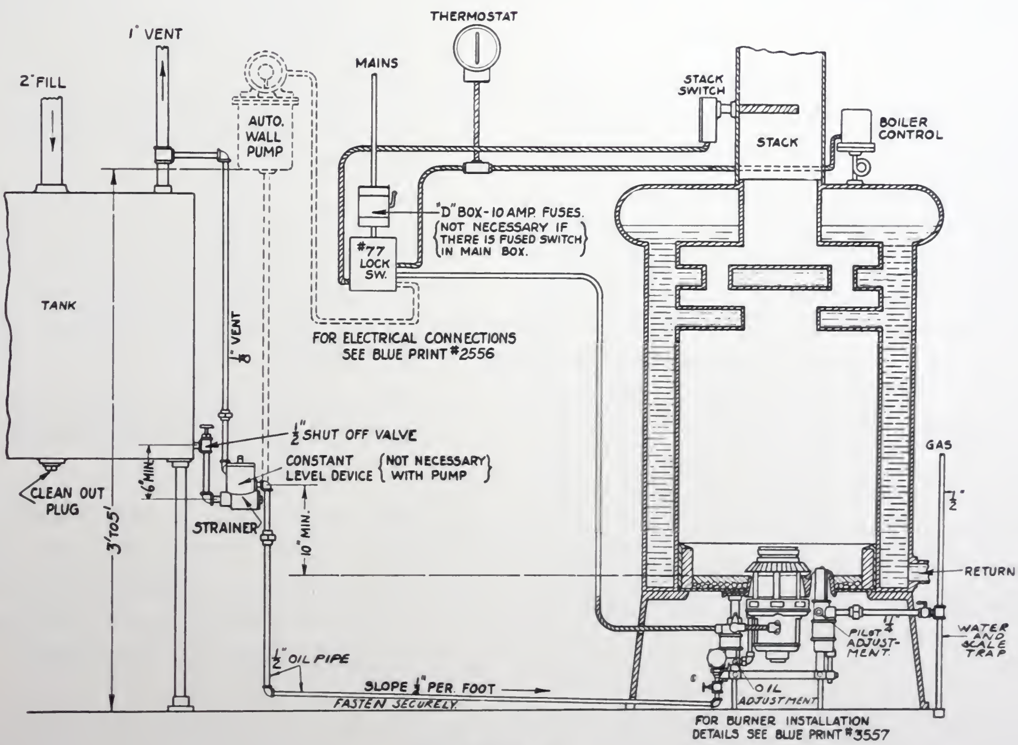


Figure 9

regulators are generally known as "Balanced Check Drafts" although they are manufactured under various trade names.

Oil Feed: Domestic burners operating from inside storage tanks can be fed by gravity direct from the tank when the supply of oil is properly controlled. Consequently no pump is necessary.

Where an underground storage tank is used, an automatic wall pump serves to transfer the oil from the tank to the wall reservoir, which provides a gravity head for feeding the burner. The wall pump being above the tank level makes the use of anti-syphon valves unnecessary.

Even when a pump is provided as a part of the burner, the automatic wall pump is often advisable as a feeder to overcome suction difficulties and eliminate air entrained in the suction line. Gravity feed from an automatic wall pump or inside storage tank is generally preferred, as illustrated in Fig. 9.

Preparing Oil for Combustion: Years of experience have proved that mechanical atomization is the only satisfactory method of preparing oil for combustion. Proper atomization means that the oil is broken up into minute particles that are so quickly gassified when discharged into the flame that they are completely burned in suspension. It is necessary that the flame temperature be sufficiently high to consume the particles of free carbon which are present in the oil. If unconsumed oil is discharged against any relatively cool surface incomplete combustion results. High speed rotary burners, atomize the oil so thoroughly that the resultant mist or fog actually floats in the air.

The practice of vaporizing oil, whether on a hot plate or when mechanically distributed over a refractory surface generally results in a cracking process which leaves the heavier constituents unconsumed, causing deposits of tar, asphalt or cabon, which soon prove troublesome. Even with the very lightest oils such burners require frequent cleaning. Vaporizing burners are not well adapted to automatic operation as the burner parts must attain a certain temperature before vaporization can be accomplished and a lazy, smoky, after fire generally results when the burner is stopped.

Type of Flame: The type, shape, size, temperature and color of flame produced by the burner is of vital importance as it governs the application of heat to the boiler or furnace. The following features are essential.

1. The fire should be well distributed over the grate area, and as near the grate level as possible.
2. The flame should not come into contact with the relatively cold walls of the firebox.
3. The flame should "float," that is burn the atomized oil in suspension.
4. Combustion should be in the presence of, but not in contact with, a refractory surface.
5. The temperature of the flame must be high enough to insure combustion of "free carbon."
6. The flame must be of a "radiant" color in order to utilize the direct heating surface. A bright orange color is most effective. Blue or dark flames are least efficient in this respect.

Gas Ignition: Gas is generally accepted as the most satisfactory ignition. The ignitor should be provided with a small permanent pilot and a large auxiliary jet, which is turned on during the ignition period only. These features should be incorporated in a single unit mounted as an integral part of the burner.

Electrical Ignition: Electrical ignition should be used where gas is not available. The most satisfactory electric ignition consists of a simple pair of electrodes supplied with high voltage from a "step up" transformer. The arc should be cut out after combustion is established to prevent radio interference. Complicated and delicate ignition devices are to be avoided.

Mechanical Design: Simplicity is the keynote to good mechanical design. The burner unit should be compact, accessible and preferably located entirely within the ashpit of the heater. All parts should be of unit construction, easily removed and replaced. The air and oil adjustment should be simple and positive. Materials and workmanship should be of the highest quality.

General: The burner should be manufactured by an organization of sufficient experience, size and financial standing to assure a uniformly high quality of product and a permanent dealer organization.

Fuel Oils: Specifications and Recommendations

Standard specifications for fuel oil have been adopted by the National Board of Fire Underwriters, American Oil Burner Association and others.

The oils suitable for automatic burner use are designated as "Furnace Oils" No. 1, 2 and 3 respectively. Those for Industrial use as "Fuel Oils" No. 4, 5 and 6.

NO.	GRAVITY	FORMERLY CALLED
1 Furnace Oil, Light	36-40	Distillate
2 Furnace Oil, Medium	32-36	Gas Oil
3 Furnace Oil, Heavy	28-32	Light Fuel Oil
4 Fuel Oil, Light	24-28	Medium Fuel Oil
5 Fuel Oil, Medium	18-24	Heavy Fuel Oil
6 Fuel Oil, Heavy	12-18	Very Heavy Fuel Oil

Summary of A.O.B.A. Furnace Oil Specifications

Specification	No. 1	No. 2	No. 3
Gravity	36-40	32-36	28-32
Flash Point, Max	165°	190°	200°
Viscosity, Saybolt, Max.			55
End Point, 90% Max	600	620	675
Pour Point, not less than	0° F	0° F	0° F
Water and Sediment	.05%	.05%	0.10%

Typical Analysis of Oil Fuels

ITEMS	SAMPLE NO. 1	SAMPLE NO. 2
Specific Gravity at 60/60 Deg. F	0.8353	0.8542
Degrees Baume	37.60	33.93
Flash Point, Deg. F. (closed cup)	155	192
Flash Point, Deg. F. (Cleveland Open Cup)	170	200
Fire Point, Deg. F. (Cleveland Open Cup)	175	210
Viscosity, Saybolt—		
Universal, at 70 Deg. F	42	48
Universal, at 100 Deg. F	40	44
Universal, at 120 Deg. F	38	40
	FURNACE OIL	FUEL OIL
Gallons per Pound	0.1437	0.1405
Per cent of water	None	None
Color of Oil	Yellow	Black
Gross B.t.u. per lb	19,934.5	19,235.5
Gross B.t.u. per gallon	138,723	136,907
Proximate Analyses—		
Volatile Matter %	99.933	99.998
Fixed Carbon %	0.067	0.012
Ash %	None	None
Ultimate Analyses—		
Carbon	83.39	84.27
Hydrogen	12.98	12.85
Sulphur	0.69	0.36
Oxygen and Nitrogen	2.94	2.52

Only the "Furnace Oils" are recommended for automatic burner use and these in accordance with the size of the heating plant. Only the larger jobs will operate

satisfactorily on No. 3 Oil without occasional cleaning and adjustment. There can be a wide variation in oils that come under the same classification. In fact, some grades of No. 3 are more satisfactory fuel than some grades of No. 2. Therefore, it is advisable to select the best of the fuels available in the local market. Red or straw colored oils contain practically no sediment, while black oils may have considerable free carbon or sediment in suspension. Such suspended sediment cannot be removed by straining and is an oftentimes unsuspected cause of trouble. It is advisable to use clear colored oils, free from sediment and the smaller the job the better the grade of oil that should be selected. Dealers acquainted with the market can usually give more dependable information on oils than can be obtained elsewhere.

Domestic Hot Water Supply

There are several methods in use for securing the domestic hot water supply directly or indirectly from an oil heated boiler.

1. Direct from Coil in Firebox: The earliest and still widely used system of installing a pipe coil or cast iron heater in the firebox supplies plenty of hot water during the winter months only. This system has the advantage of low installation cost, but is not satisfactory during mild weather and of no use during the summer

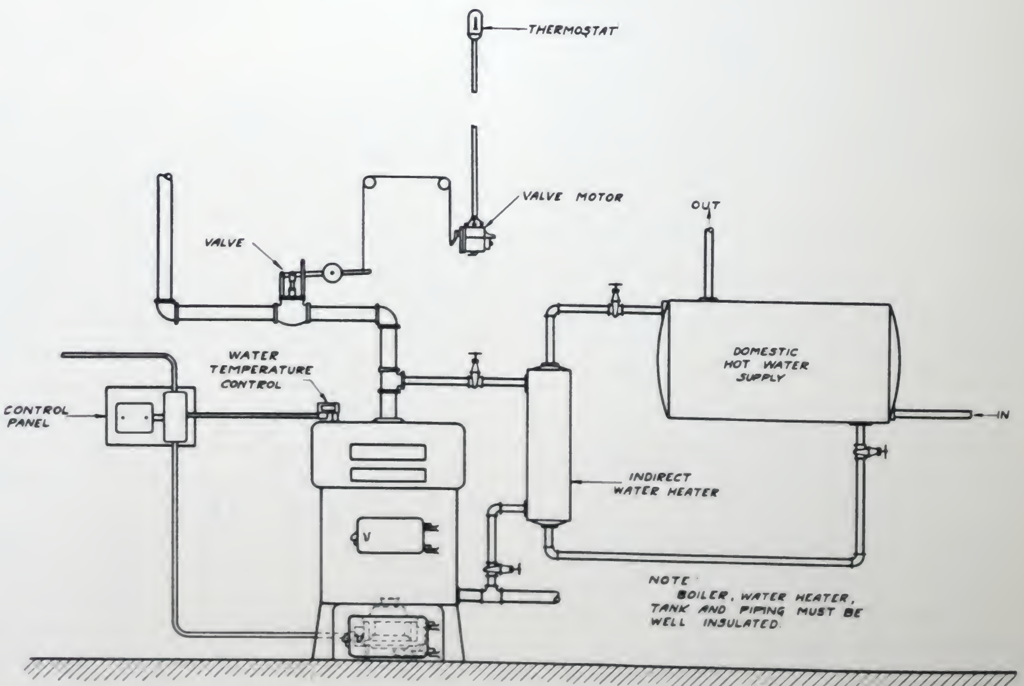


Figure 10A—Domestic Hot Water Supply from Oil Burner Installed in Hot Water Heating System

months. It can only be recommended for warm air and possibly hot water heating systems.

2. Indirect Water Heaters: Consisting of a cast iron shell enclosing a copper coil are widely used with steam, vapor and even hot water systems. Such installations are shown in Figs 10 and 10A. The shell is connected to the boiler below the water line and the copper coil is connected to the hot water supply tank. The tank should be horizontal and completely above the level of the heater. Sectional steam boilers must have a tap in each section at the top as there are no openings between the sections near the water line and the untapped sections are likely to steam. A single return connection to the bottom of the boiler is sufficient. Vertical boilers require only a single connection at the top as well as at the bottom.

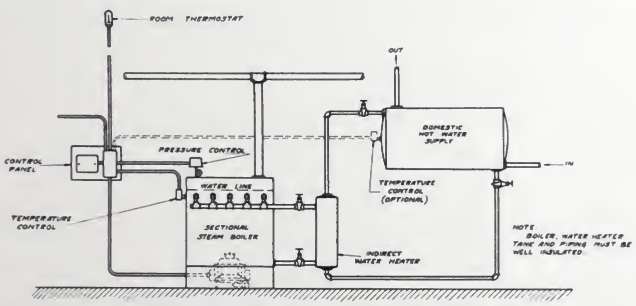


Figure 10—Domestic Hot Water Supply from Oil Burner Installed in Steam Heating System

With such a system a hot water boiler control, inserted in the heater below the water line, is connected in parallel with the room thermostat. The hot water control is set to maintain a water temperature of from 140° to 180°, which is sufficient for heating the domestic hot water, but of course does not furnish heat to the radiators, as no steam is produced. The room thermostat controls the burner in the usual manner when there is a demand for heat, steam being produced very quickly, due to the fact that the water is always maintained at a temperature close to the boiling point. It is necessary to have the boiler, storage tank and piping well insulated to prevent unnecessary radiation losses.

This system can be adapted for use with hot water boilers by installing motor operated valves in the risers,—these valves being operated from the room thermostat.

Separate Tank Heaters: Where the demand for hot water is exceptionally heavy, a separate boiler is often advisable. The water heating boiler should be of efficient design with a grate diameter not less than 16 inches. Allow 2 sq. ft. steam rating for each gallon of hot water storage in selecting boiler. The installation of another burner for this purpose will cost very little, as no additional thermostat, pump or tankage is required.

Additional Information on this subject can be obtained from the Excelso Heating Specialties Co., Buffalo, N. Y.; Taco Heaters, Inc., New York City; or from handbooks published by the American Radiator Co., and others.

Individual Thermostatic Control

It is often desirable to have separate temperature control in individual apartments or in the separate wings of a large residence where the exposures are quite varied. In such cases, it is perfectly practicable to operate the burner from the boiler control, having individual thermostatically controlled valves to supply heat to various sections of the building. The initial investment in controls will often be completely offset by the saving in fuel, as

in the case of heating an apartment building where one tenant will have his windows open while another will be wanting more heat. Such layouts as are submitted are worthy of consideration and many variations will suggest themselves.

An example of such a layout is shown in Fig. 11.

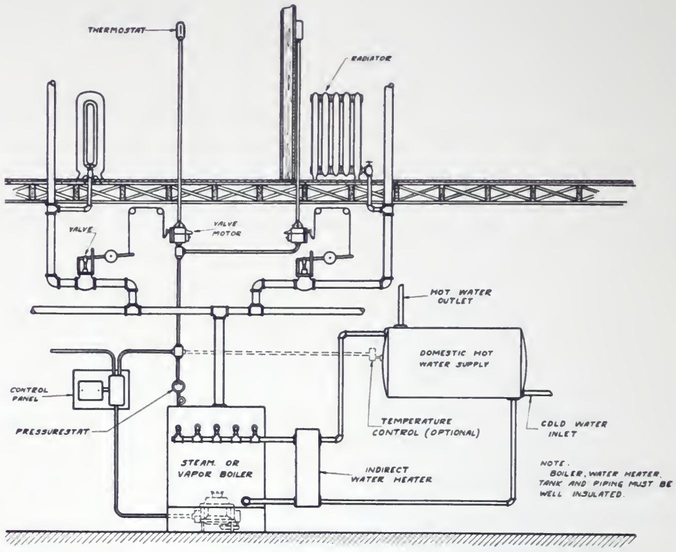


Figure 11—Individual Thermostatic Control for Apartments, etc., Using Oil Heat

Conversion Units

The following tables will be found useful in converting from one unit of measurement to another. For instance, oil in feet to equivalent inches of mercury; boiler horsepower to kilowatt hours, etc.

Air and Oil Data

1 lb. Air	=13.34 cu. ft.
1 cu. ft. Air	= .0750 lbs.
1 lb. Oil requires	14.03 lbs. air for perfect combustion
	16.84 lbs. air 20% excess
	19.64 lbs. air 40% excess
	22.45 lbs. air 60% excess
	25.25 lbs. air 80% excess
	28.06 lbs. air 100% excess
1 lb. Oil 35° Be.	= .141 gals.
1 gal. Oil 35° Be.	=7.065 lbs. sp. gr.=.8485

1 gal. Oil requires:

EXACT LBS.	APPROX. LBS.	CU. FT.	% EXCESS	CO_2
99.2	100	1320	0	15.395%
119.0	120	1587	20%	12.69
138.8	140	1850	40	10.79
158.6	160	2120	60	9.38
178.3	180	2380	80	8.30
198.3	200	2640	100	7.45

Air—79.09% Nitrogen 20.91% Oxygen by Volume
76.85% Nitrogen 23.15 Oxygen by Weight

1 cu. ft.=7.48 gals.

1 lb. Oil Evaporates 20 lbs. water f. & a. 212° @ 100% efficiency.

1 lb. Oil Evaporates 16 lbs. water f. & a. 212° @ 80% efficiency.

1 lb. Oil Evaporates 12 lbs. water f. & a. 212° @ 60% efficiency.

Weights

1 cu. ft. air weighs	.0750 lbs.
1 cu. ft. water weighs	62.4 lbs.
1 cu. ft. oil weighs	52.85 lbs.
1 cu. ft. mercury weighs	847.5 lbs.
1 cu. in. water weighs	.0361 lbs.
1 cu. in. oil weighs	.0307 lbs.
1 cu. in. mercury weighs	.4902 lbs.
1 gal. water weighs	8.33 lbs.
1 gal. oil 35° weighs	7.065 lbs.

Pressure Data

1 Atmosphere = 14.7 pounds per sq. in.
= 30 inches of mercury
= 33.947 ft. water
= 40.0 ft. of oil 35° Be.

1 oz. Pressure = .063 pounds per sq. in.
= .128 inches of mercury
= 1.73 inches of water
= 2.04 inches of oil = 17 ft.

1 lb. Pressure = 1.0 pound per sq. in.
= 2.04 inches of mercury
= 2.31 ft. of water
= 2.72 ft. of oil

1 in. Mercury = 7.86 oz. per sq. in. = .49 lbs. "D"
= .49 lb. per sq. in.
= 13.58 inches of water
= 1.132 ft. of water
= 16.0 inches of oil
= 1.33 ft. of oil

1 ft. Water = .433 lbs. per sq. in.
1 ft. Oil = .402 lbs. per sq. in.

Power Data

1 Kilo Watt = 1000 Watts
= 1.34 Horsepower
= 3420 B.t.u. per hour

1 Watt = 3.42 B.t.u. per hour
1 Engine Horse Power = .746 Kilo Watts
= 746 Watts
= 33000 Ft. pounds per min.
= 2550 B.t.u. per hour
= 2.63 lbs. Water Evaporated per hour
= .316 Gals. Water Evaporated per hour

1 Boiler Horse Power = 33478.8 B.t.u. per hour
= .34 Gals. oil per hr. at 70% eff.
= 34.5 lbs. Water Evaporated per hr. (from and at 212°)
= 4.14 Gals. Water Evaporated per hr.
= 9.8 Kilo Watt hours
= 13.1 Engine Horse Power

B. T. U. Data

1 B.t.u. = Heat required to raise 1 lb. of water 1° F.
1 gal. oil contains 140000 B.t.u.
1 gal. oil delivers 98000 B.t.u. @ 70% eff.
1 sq. ft. Steam Radiation emits 240 B.t.u. per hr.
1 sq. ft. Vapor Radiation emits 200 B.t.u. per hr.
1 sq. ft. Hot Water Radiation emits 150 B.t.u. per hr.
1 sq. in. Hot Air pipe carries 138 B.t.u. per hr. (Av. 1 & 2 floor)
1 sq. in. Hot Air Grate Surface develops 300 B.t.u. per hr.

Test Reports

The following condensed reports, prepared by reputable authorities, cover tests of ABC Burners in various types of boilers and furnaces. They show what high overall efficiencies may be obtained by using suitable oil burners in boilers and furnaces of standard design.

Complete copies of original reports will be furnished on request.

DEPARTMENT OF ENGINEERING RESEARCH

UNIVERSITY OF MICHIGAN
ANN ARBOR

Test of the Du Brie Hot Air Furnace Purpose

The purpose of this test was to determine the stack loss and probable efficiency of the Du Brie Hot Air Furnace.

Test

The Test consisted of taking readings of carbon dioxide and oxygen and temperatures in the stack. These readings were taken at intervals of approximately 15 minutes until 2:57 p.m.

Average Stack Analysis

14.45% CO_2
1.16% CO_2 at 484.9° F.
84.39% N_2

Results

The losses in the stack are:

	B.t.u.	Percent of Heat Supplied
1. Heat lost in dry stack gases	1477.6	7.58

2. Heat lost in evaporating moisture formed on combustion of the hydrogen in the oil......1317.2 6.76
3. Heat lost in superheating vapor in stack............. 238.6 1.22

High heating value of oil.................19471 B.t.u.

Furnace and Burner Eff. based on total heat 84.44%

On a colder day, losses 1 and 3 could have been reduced because of the fact that the dome temperature would have been lower and, consequently, the stack temperature would have been reduced.

The total loss up the stack is 15.56% of the fuel as fired and this gives an overall efficiency of 84.4%. This is a very good efficiency, especially when we consider that the loss due to latent heat cannot be reduced, due to the fact that the water vapor cannot be eliminated. Thus, we find 1317.2 B.t.u. unavailable for heating purposes. If we deduct this from the total heat in the oil, we find 18153.8 B.t.u. available for heating purposes. In this way, we find that the furnace under test conditions was utilizing 90.5% of the available heat. This, as mentioned above, could be increased in colder weather by about 2%, or perhaps better.

Report of ABC Oil Burner

Prepared by
ARA MARCUS DANIELS, E.E.
Consulting Engineer
(Heating and Ventilating)
Woodward Building Washington, D.C.
Formerly
Mechanical Engineer in Charge of
Domestic Oil Burner Tests for U. S.
Government.

Purpose of Tests

The tests reported herein were conducted for the following purposes:

(a) To determine general operating characteristics of the ABC Oil Burner when installed in a round coal-burning water boiler.

(b) To determine overall plant efficiency and available heat supplied the heating system for different rates of fuel consumption.

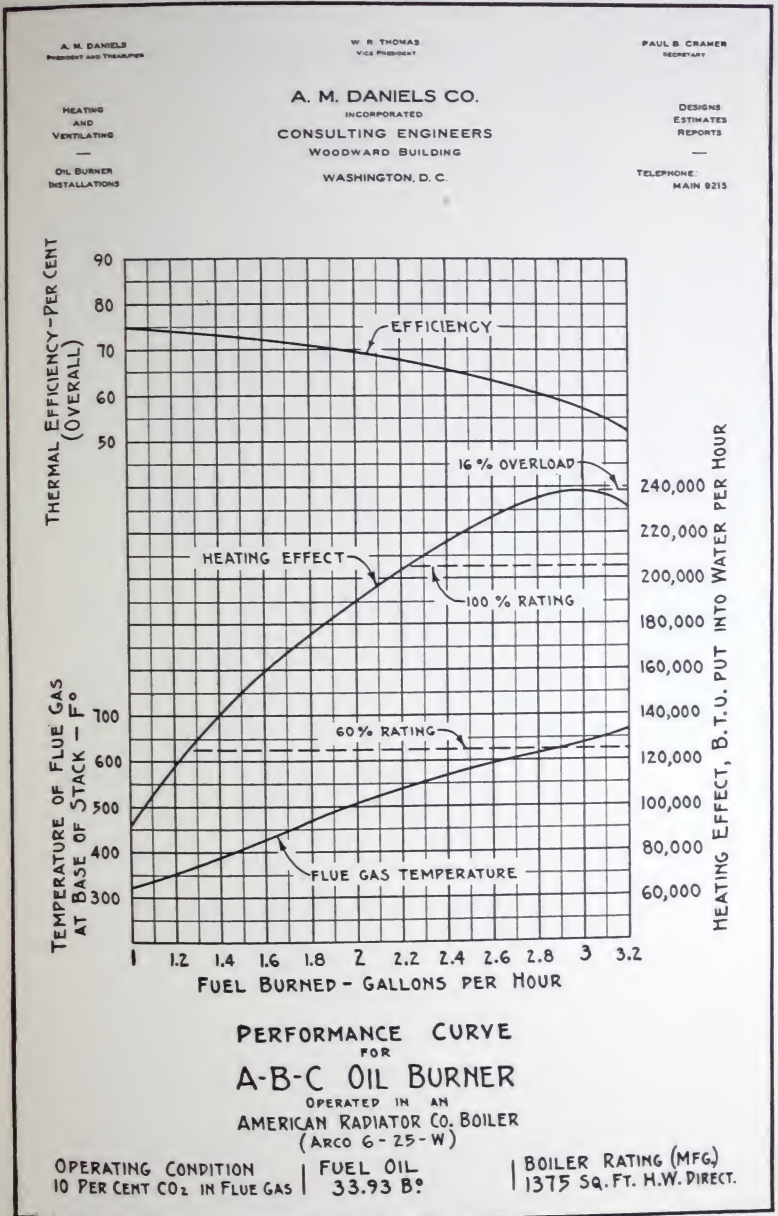
(c) To determine the effect of length of flue gas travel on overall efficiency.

(d) To obtain a comparison of burner operation with oils of different gravities.

(e) To study heat distribution at different rates of fuel consumption.

Analysis of Tests

While all the tests conducted afford valuable data from a scientific point of view, only the series during which the burner and plant were operated to secure a flue gas having 10 per cent carbon dioxide content are analyzed in this report since the conditions obtained during these series are believed most closely to represent those attending burners as installed and operated in private residences.



Test "B"

Date	3-24-25
Duration of Test—Hours	1
Heater Used, Arco	6-25-W
Fuel Oil, Gravity	33.93 B°
RATES	
Fuel Burned, Pounds per Hour	8.76
Fuel Burned, Gallons per Hour	1.231
DRAFT	
Base of Flue, Ins. of Water	+0.019
Combustion Chamber, Ins. of Water	0.000
Ash Pit, Ins. of Water	——
TEMPERATURES, FAHRENHEIT	
Fuel	69°
Surface Smoke Pipe	197°
Flue Gas	359°
Air to Ash Pit	67°
FLUE GAS ANALYSIS	
Carbon Dioxide, per cent by volume	9.4
Oxygen, per cent by volume	8.0
Carbon Monoxide, per cent by volume	0.0
Nitrogen, per cent by volume (difference)	82.6
HEAT BALANCE PER POUND OF FUEL AS FIRED	
a. Heat Imparted to Tank Water, B. t. u.	14,297
b. Heat Lost Due to Moisture Content of Fuel, B. t. u.	0
c. Heat Lost Due to Water Vapor Formed in Burning Hydrogen, B. t. u.	1370
d. Heat Lost Due to Moisture in Air Used for Combustion, B. t. u.	22
e. Heat Carried Away by Dry Chimney Gases, B. t. u.	1545
f. Heat Lost by Radiation from Heater and Smoke Pipe, B. t. u.	444
g. Heat Lost Due to Unconsumed Gaseous Combustible Matter, B. t. u.	0
h. Heat Lost Due to Unconsumed Combustible Soot, B. t. u. Heat Lost Due to Convection and Unaccounted Losses, B. t. u.	1558
. Total Heat Value of Fuel as Fired, B.t.u., per pound	19,236
HEAT BALANCE, PER CENT HEAT IN FUEL AS FIRED	
a. Heat Imparted to Tank Water (thermal efficiency), per cent	74.3
b. Heat Lost Due to Moisture Content of Fuel, per cent	0.0
c. Heat Lost Due to Water Vapor Formed in Burning Hydrogen, per cent	7.1
d. Heat Lost Due to Moisture in Air Used for Combustion, per cent	0.1
e. Heat Carried Away by Dry Chimney Gases, per cent	8.0
f. Heat Lost by Radiation from Heater and Smoke Pipe, per cent	2.3
g. Heat Lost Due to Unconsumed Gaseous Combustible Matter, per cent	0.0
h. Heat Lost Due to Convection and Unaccounted Losses, per cent Heat Lost Due to Unconsumed Combustible in Soot, per cent	8.2
Total Heat Value of Fuel as Fired, per pound	100.0
Total Per Cent Delivered as Useful Heat (a + f + ½h)	80.7
ELECTRIC POWER, D.C.	
Volts	112.1
Amperes	0.3
Watts	33.6

Conclusions

The tests indicate this burner to be particularly suited to types of coal burning boilers commonly used for residence heating.

Its behavior at all rates of combustion was excellent: practically no carbon deposits occurred after long periods of operation: it operated with practically no noise and with a conservative carbon dioxide content in the flue gases: it produced an extremely high overall plant efficiency.

Results of Tests

No. 5 KNOLTON WATERTOOB BOILER RATING 1300 SQ. FT.
STEAM OIL FIRED

Test No	1	2	3	4
Duration Test Hours	1.75	4	4	4
Average Quantities				
Feed Water Temp. Deg. F	72.4	74.0	72.3	72.3
Stack Temp. Deg. F.	306.6	365	407.3	464.1
Room Temp.	86.1	85.5	87.2	84.5
Steam press lbs. sq. in. Abs	14.45	14.48	14.51	14.53
Draft up take inches—water	.020	.023	.025	.045
C. O. 2%	11.6	14.2	14.9	14.2

TOTAL QUANTITIES

Total water fed boiler, bls.	295.2	1002.8	1153.1	1429.3
Total oil burned, lbs.	21.09	70.69	81.88	130.45
Total oil burned, gals.	2.906	9.53	11.31	14.27
Totalcondensation, lbs	2.45	7.17	11.3	13.73
Quality of Steam	99.11	99.29	99.02	99.04
Factor of Evaporation	1.1345	1.1347	1.1337	1.1334
Equivalent evaporation from and at 212° F.	334.9	1137.8	1307.1	1620

AVERAGE HOURLY QUANTITIES

Water feed to boiler, lbs.	168.5	250.7	288.2	357.3
Oil burned, lbs	12.05	17.67	20.47	25.86
Oil burned, gals.	1.66	2.43	2.82	3.56
Equivalent evaporation lbs.	191.3	284.4	326.8	405

ECONOMIC RESULTS

Equivalent evaporation per lb. in oil	15.87	16.09	15.96	15.65
Percent rated capacity developed	59.5	88.5	101.5	126.0
Overall efficiency burner and boiler	80.19	81.34	80.64	79.12

Barometer—29.40

The above test data was obtained from a report submitted by G. F. Gebhardt, M.E., of the Armour Institute of Technology who supervised the test.

Test was made using an oil of 29.8 gravity—19,214 B.t.u.'s per lb.

Installation and Architect's Specifications

BURNER INSTALLATION: Every burner has its own peculiarities of design, mechanical details, installation features and adjustment. Consequently burners should only be installed by experienced, well trained representatives of the manufacturer.

This applies also to the installation of accessory equipment, such as controls, tanks, pumps and piping which must be installed in accordance with the requirements of the particular burner under consideration.

The Laboratories of the National Board of Fire Underwriters, 207 E. Ohio St., Chicago, supply on request booklets containing regulations on the installation of oil burners, oil storage, and accessory equipment.

The following specifications have been prepared by the American Oil Burner Association as a guide to architects.

OUTLINE OF ARCHITECT'S SPECIFICATIONS

COVERING THE INSTALLATION OF OIL HEATING EQUIPMENT

Scope of Contract: These specifications cover the complete installation of an oil heating apparatus and fuel oil storage system, for the boiler installed in.

The apparatus shall consist of an ABC oil burner, fuel oil storage tank (tanks); room thermostat, boiler control, burner safety device, necessary and adequate installation of refractory lining in the combustion chamber of the boiler, all necessary piping, valves, electric wiring, switches, etc., all tested and ready for operation.

The oil heating installation shall comply with all local ordinances (or rules of National Board of Fire Underwriters), and must meet available electric current facilities.

Liability: The contractor shall assume, etc., etc.

Completion of Work and Payment: The work is to be completed, etc.

Materials: All materials, etc. (recommended furnished by contractor).

Cutting and Patching: The contractor shall do all, etc.

Cleaning Up: The contractor shall promptly, etc.

Additional Data: All visible piping and scratched places will be painted to match other new similar adjacent material.

Oil Burning Apparatus: The contractor shall furnish, make all necessary changes in the boiler (or furnace) and install, one completely equipped ABC oil burner, etc.

Fuel Oil Storage: The contractor shall furnish and install (one . . . . gallon inside) fuel oil storage tank. Tanks shall be manufactured, tested and installed in accordance with local regulations (or rules of National Board of Fire Underwriters).

Piping: Piping shall be installed in accordance with local regulations (or rules of National Board of Underwriters).

Wiring: All wiring shall be done in accordance with the National Electric Code, and local regulations.

Thermostat Control: The thermostat shall be installed in . . . . room, five feet from floor, removed as far as is practical from any and all warming influences such as radiators, hot water pipes, etc., or possible cooling drafts.

Warm Air Furnace Control: Furnaces shall be equipped with thermostatic warm air

jacket control, wired in connection with room thermostat.

Boiler Control: A maximum pressure or temperature control shall be installed in the boiler according to manufacturer's printed instructions. This control shall be wired so as to automatically prevent creation of excessive pressure or temperature in the boiler.

Burner Safety Device: A burner safety device shall be installed in connection with the burner, so designed as to make the burner inoperative if for any reason the burner does not function properly.

In General: The omission from these specifications of any minor detail of construction, installation, material, specialties, etc., shall not relieve the contractor from furnishing same in place complete, and such omissions shall not entitle contractor to make claims or demands for extra materials or labor. However, in the event that unusual water is struck or if quicksand, rock or other unusual obstructions are encountered, the contractor shall proceed with the necessary special construction that is involved for which the contractor will receive sum equal to the actual cost of such special work plus.......... percent. The word "cost" as hereinabove used shall be understood to consist of actual field cost and overhead.

Adjustment: The contractor shall agree to provide free inspection and adjustment of the oil burner installation for the first ninety days of the heating season during which the installation is made. The heating season shall be considered as beginning September first for installations made during the summer.

Guarantee: The contractor shall guarantee to make good by replacement or repair, any original defects in parts, material or workmanship previously specified or described; provided that this obligation is assumed only in the event that written notification of such alleged defect be given the contractor within a period of one year after said equipment has been installed.